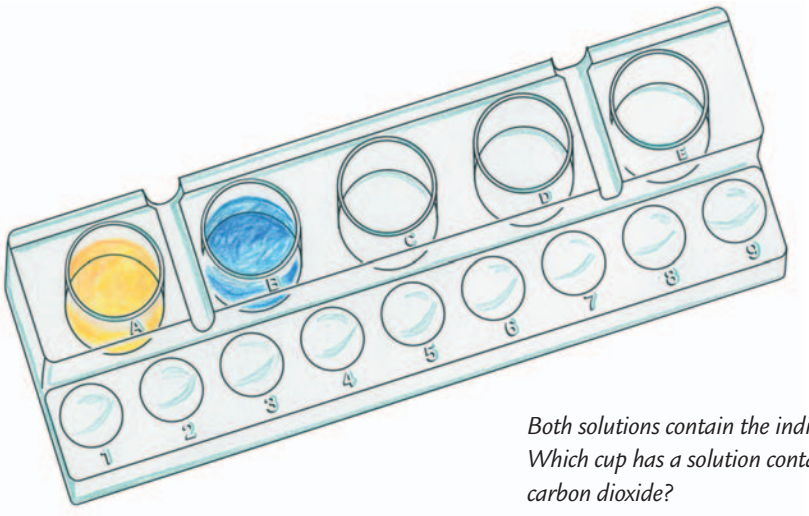
17 Gas Exchange

Your blood transports the nutrients that you eat to different parts of your body. It also carries oxygen from your lungs to other organs and tissues. Your lungs are part of your **respiratory system.** With every breath you take, you inhale oxygen and exhale carbon dioxide. Your body uses the oxygen to get energy from food. When your body breaks down food, it produces wastes. One of the wastes is carbon dioxide.

Indicators (IN-duh-kay-ters) are chemicals that change their appearance in different types of solutions. You will work with the indicator bromthymol (brome-THY-mall) blue, also known as BTB. BTB can be either blue or yellow. When added to a solution containing carbon dioxide, BTB is yellow.



Both solutions contain the indicator BTB. Which cup has a solution containing carbon dioxide?

CHALLENGE **How much carbon dioxide is in your exhaled breath?**

SAFETY

In this activity, you will be blowing through a straw into chemicals. Do not inhale through the straw! Breathe in through your nose and exhale through your mouth. If you accidentally swallow liquid, rinse your mouth thoroughly and drink plenty of water. Be sure to tell your teacher.

MATERIALS

For each group of four students

- 1 dropper bottle of bromthymol blue (BTB) indicator
- 5 plastic cups
- supply of water

For each pair of students

- 1 dropper bottle of 0.05 M sodium hydroxide
- 1 SEPUP tray
- 1 dropper
- 1 30-mL graduated cup

For each student

- 1 1-gallon plastic bag
- 1 straw
- 1 stir stick
- access to a wall clock or watch with a second hand
- 1 Student Sheet 17.1, "Anticipation Guide: Gas Exchange"

PROCEDURE

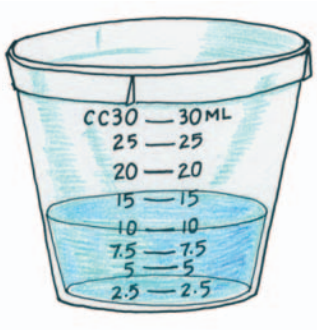
Use Student Sheet 17.1, "Anticipation Guide: Gas Exchange," to prepare you for learning about the respiratory system. Read each statement, and complete the "Before" column only.

Part A: Using BTB to Test for Carbon Dioxide

1. Work with your partner to add 5 mL water to each of the five large cups (A–E) of your SEPUP tray. Use the 30-mL graduated cup to measure the water.
2. Add 2 drops of BTB to each cup and stir.
3. Create a data table to record the initial and final colors of the solutions in each cup. Record the initial colors now. Cup A will provide a control.
4. Use your dropper to bubble air into Cup B. Place the dropper into the solution and press the air out of the bulb. Before releasing the bulb, remove the tip from the solution. This will prevent uptake of solution into the dropper. (If you accidentally get solution into the dropper, simply squirt it back into Cup B.) Repeat this for 15 seconds.
5. Record the final color of the solution in Cup B in your data table.

6. Add 3 drops of 0.05 M sodium hydroxide to Cup C. Record the final color in your data table.
7. Unwrap your straw and place one end in Cup D. Take a deep breath, and then gently blow through the straw for 15 seconds. (Remember not to inhale through the straw!) Record the final color of the solution in Cup D in your data table.
8. Have your partner blow through a clean straw into Cup E for 15 seconds. (Remember not to inhale through the straw!) Record the final color in your data table.
9. Add 3 drops of sodium hydroxide to Cups D and E. In your science notebook, record any changes that you observe.
10. Work with your partner to complete Analysis Questions 1 and 2.

Part B: Using BTB to Measure Carbon Dioxide in Exhaled Breath



11. Work with another pair of students to set up a control:
    a. Measure 10 mL of water using the 30-mL graduated cup.
    b. Add 5 drops of BTB to the graduated cup and stir.
    c. Pour the BTB solution into a large plastic cup. This solution will be the control for every member of your group.
12. Have each person in your group set up his or her own bag of BTB solution:
    a. Measure 10 mL of water using the 30-mL graduated cup.
    b. Add 5 drops of BTB to the graduated cup and stir.
    c. Pour the BTB solution into your own 1-gallon plastic bag.
13. Remove the air from your plastic bag by slowly flattening it. Be careful not to spill any of the BTB solution out of the bag. While keeping the air out of the bag, place a straw in the mouth of the bag. Make an air-tight seal by holding the mouth of the bag tightly around the straw.

14. Be sure you are sitting down. Then fill the bag with air from your lungs by blowing through the straw until the bag is fully inflated. When you finish blowing, pull out the straw. As you pull out the straw, squeeze the bag tightly shut so no air escapes.

15. Holding the bag closed, shake the bag vigorously 25 times.

16. Pour the BTB solution from the bag into a clean, empty plastic cup.

17. *How much carbon dioxide is in your exhaled breath?* You can find out by counting how many drops of sodium hydroxide are needed to make your BTB solution the same color as the control:

    a. Add 1 drop of sodium hydroxide to your plastic cup.

    b. Gently stir the solution and wait at least 10 seconds.

    c. Record in your science notebook that you added 1 drop.

    d. Compare the color of your solution to the control. *Is it the same color as the control for at least 30 seconds?*

    If your answer is no, repeat Steps 17a–d. Be sure to keep track of the total number of drops!

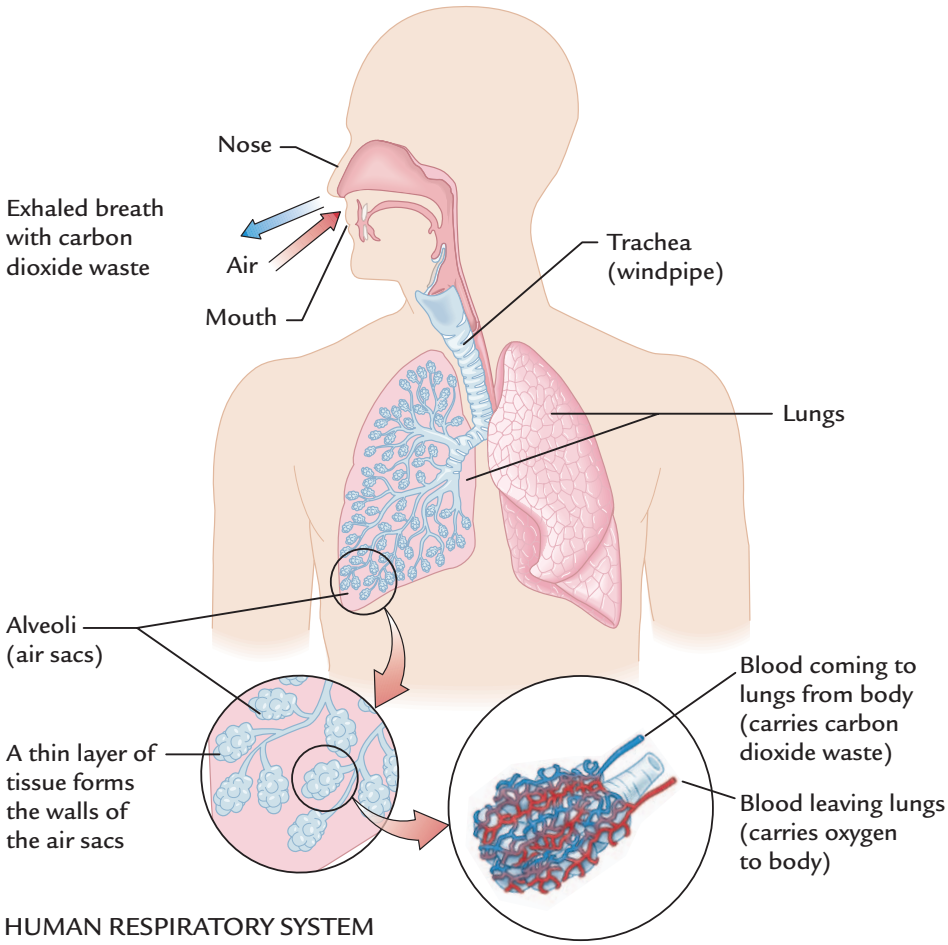
    If your answer is yes, go on to Step 18.

18. In your science notebook, record the total number of drops it took to change your solution back to the same color as the control. Then record your total on the class data table.

19. Draw a bar graph with the class results. Remember to title your graph and label the axes!

EXTENSION 1

Do you exhale more carbon dioxide after you hold your breath? Find out by modifying and repeating Part B of the Procedure.



HUMAN RESPIRATORY SYSTEM

This is a plastic mold of the air ways and air sacs in the lungs. Compare it to the diagram of the lungs above.

ANALYSIS

Part A: Using BTB to Test for Carbon Dioxide

1. What was the purpose of the solution in Cup A?

2. **a.** Which of the solutions in Part A contained carbon dioxide? Support your answer with evidence from your experimental results.

   b. What does this tell you about the exhaled breath of human beings?

   c. Look at the table below. Compare the composition of air you breathe in to that of air you breathe out. Describe the differences.

Composition of Breath

Components of earth's atmosphere	Composition of air breathed in (%)	Composition of air breathed out (%)
Nitrogen	78	75
Oxygen	21	16
Argon	0.9	0.9
Carbon dioxide	0.035	4.0
Water vapor	0.4	4.0

Part B: Using BTB to Measure Carbon Dioxide in Exhaled Breath

3. Review the class data table. What was the range of carbon dioxide in exhaled breath (as measured by drops of sodium hydroxide)?

4. Look again at the diagram of the human respiratory system. Considering all the oxygen that has to get into your blood and all the carbon dioxide that has to escape from your blood, why do you think the inside of the lung is structured the way it is?

5. **a.** Were the data collected in Part A qualitative or quantitative? Explain.

   b. Were the data collected in Part B qualitative or quantitative? Explain.

6. **a.** Look carefully at the diagram of the human respiratory system. What are some of the important structures in the respiratory system?

   b. Explain where gases are exchanged within the respiratory system.

7. Complete Student Sheet 17.1. Be sure to explain how the activity provided evidence for your initial ideas or caused you to change your thinking.

8. **Reflection:** Many respiratory diseases limit a person's capacity to exchange oxygen. One of these diseases is pneumonia, which causes the alveoli to fill up with fluid. Another is pleurisy, which is an inflammation of the lining of the lung, making it painful to inhale and exhale. If you had one of these diseases, how do you think you would feel?

EXTENSION 2

To find out more about how the lungs work and the effect of asthma on the lungs, go to the *Issues and Life Science* page of the SEPUP website

EXTENSION 3

How do you think your body gets more oxygen when you exercise? Do you breathe faster (take more breaths per minute)? Or do you absorb more oxygen from the air with each breath? Use what you learned in this activity to develop an experiment to test your hypothesis.